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(54) Screen for printing electrical circuits

(57) A printing screen, particularly for use in the printing of electrical circuits, comprises a metal foil (1) having an array of holes (2) etched through it, and a layer of a screen printing emulsion (3) applied to one surface of the foil. A pattern is formed in the emulsion (3) by removing portions of it. The holes (2) and the pattern are formed in accurate register with one another. The foil may be mounted indirectly in a printing frame by bonding the foil to a woven mesh stretched in conventional fashion on the frame and then cutting away the mesh in the general area of the pattern. If a suitably resistant emulsion is used then the etching of holes into the foil may be a later step than the pattern formation in the emulsion.

Fig. 2.

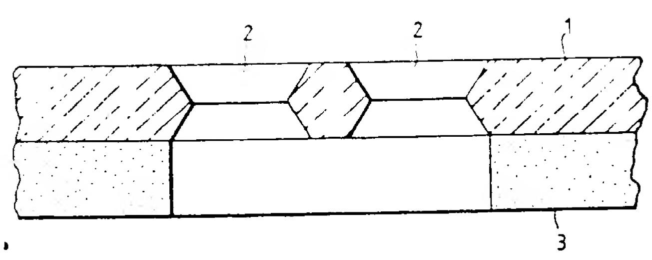

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Fig. 1.

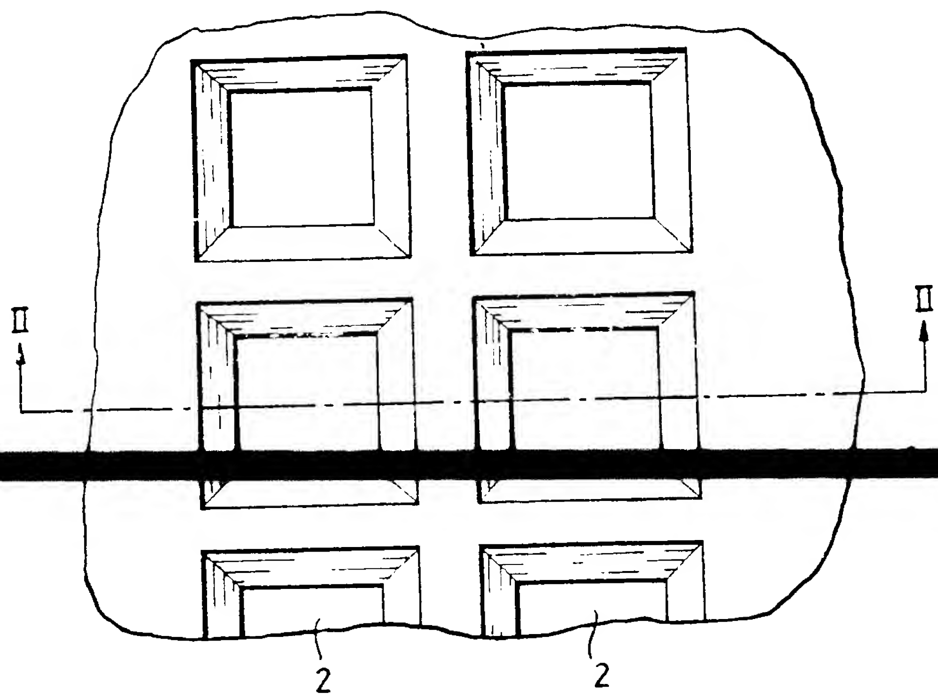
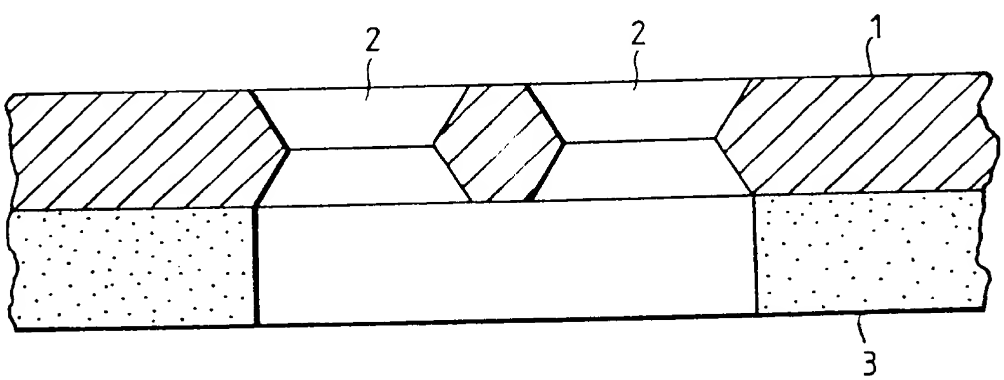


Fig. 2.



SCREEN FOR PRINTING ELECTRICAL CIRCUITS

This invention relates to a printing screen, particularly for use in the printing of electrical circuits.

The introduction of microelectric techniques into the manufacture of electronic equipment is leading to more densely packed circuitry. This trend is spearheaded by rapid developments in semiconductor technology. With improvements in processing techniques and advances in device design, very complex silicon integrated circuits are now routinely manufactured and many thousands of circuit elements can now be packed into a silicon chip only 0.5 cm square. These integrated circuits must be interconnected by conductor networks external to the chip, and these networks must also be densely packed. A preferred method of realising these interconnections is to use thick film multilayer structures.

Such structures are produced by screen printing patterns of specially-formulated printing pastes on to ceramic substrates. The printed patterns are subsequently dried and fired at high temperatures to yield electrically conductive metal layers or insulating glass ceramic dielectric layers. By printing and firing metal conductor tracks and dielectric insulation in alternate layers, multilayer structures can be produced.

Such structures have been used for many years to interconnect silicon chips. However, if conventional screen printing is used, the geometrical precision with which the circuit patterns can be produced is limited, and for fabrication of the most advanced circuitry more precise printing is required.

Screens used for printing thick film circuit patterns are conventionally made from a woven mesh, usually of stainless steel wire but sometimes of a polymer fibre. The mesh is stretched over a rectangular

metal frame and is bonded to the frame to produce a taut screen with an open mesh. A photosensitive emulsion is applied to the whole area of the screen, which totally fills the openings in the woven mesh. After drying, the emulsion is exposed to ultraviolet light through a mask which is patterned in the shape of the desired circuit. The exposed areas of emulsion are polymerised, whereas the unexposed areas are not. The unexposed material is then removed in a development process, and the remaining emulsion is baked or further exposed to ultraviolet light to yield a strong impervious coating on the screen. The pattern to be printed corresponds to the uncoated area of

In the printing operation ink is forced through the apertures in the uncoated mesh on to the surface of the substrate.

The fineness of detail which can be printed depends upon the size of the woven mesh, which in turn depends upon the diameter of the wire used to weave the mesh. In practice, wire of about 20μ diameter is about the finest which can be used for printing thick films, and the maximum mesh count is about 150 lines per cm. If the dimensions of such a screen were perfectly regular, it would be possible in principle to print lines of about 60μ width and with similar spacing. However, the spacing of wires in a woven mesh is not perfectly regular, nor are the wires perfectly straight.

Apertures in the mesh may be covered with emulsion, uncovered or partially covered. Since the printing ink, which contains particulate material, cannot be forced through the very small holes formed by partially-covered apertures in the mesh, this presents a fundamental limitation of the pattern resolution obtainable with a woven screen.

A further disadvantage is that the surface of a woven screen is not flat but consists of an array of corrugated wires. When thin emulsions are used in fine work, this lack of flatness results in a printed pattern with a wavy edge.

A further limitation of woven screens is lack of dimensional stability: relative movement of the wires occurs in flexing of the screen during the printing operation. This makes it difficult to register accurately successive patterns printed on the same substrate.

These limitations are not serious in printing relatively coarse patterns, and line widths of down to about 200μ are routinely achieved in the manufacture of thick film circuits, but more precise screens are required for finer work.

According to one aspect of this invention a printing screen comprises a metal foil having an array of holes etched through it, and a layer of a screen printing emulsion applied to one surface of the foil and having a pattern formed therein by partial removal of the emulsion, the holes and the pattern being in accurate register with one another.

According to another aspect of this invention a method of forming a printing screen, comprises the steps of etching a metal foil to form an array of holes through it; depositing a layer of a screen printing emulsion on a surface of the metal foil; and removing portions of the emulsion to form a pattern through, with the pattern in accurate register with the holes.

The holes may be etched in a continuous array but preferably they are only etched in the region in which the screen printing emulsion is removed to make the screen stronger and more stable. Where the pattern includes portions of different dimension the dimensions

of holes may vary and correspond to the dimensions or geometry of the different portions of the pattern.

Preferably the thickness of the foil is in the range 10μ to 50μ, and preferably the width of the holes etched through the foil is in the range 10μ to 50μ. The foil may be formed, for example, of stainless steel, nickel or beryllium copper. The surface of the foil may be rendered non-reflective before the emulsion is deposited on it.

An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawing, in which

screen in accordance with the invention; and

Fig. 2 is a section on a line II-II of Fig. 1.

Referring to Figs. 1 and 2, a metal foil 1 is penetrated by an array of fine holes 2. A layer 3 of a photosensitive emulsion is applied to one side of the foil. The emulsion is exposed to ultra-violet light through a mask (not shown) and is then developed to remove the emulsion in areas of the screen which correspond to a pattern to be printed. It is arranged that the holes in the foil and the printing pattern developed in the emulsion are in accurate register with each other, so that the holes in the screen are always fully open, or fully closed i.e. are not partially closed by emulsion. In the printing operation a consistent volume of ink is therefore forced through each hole, which would not be achieved by producing a screen from a foil with an array of holes which are not registered with the pattern to be printed. The accurate registration between the holes and the pattern can be achieved by ensuring that the dimensioning of the art work for the holes accurately matches the dimensioning of the art work for the pattern. When the art work for the pattern

includes lines of different width the aperture size of the holes inthe lines of different width maybe different and their geometry may vary with the dimension and shape of the pattern. The mask for the pattern is then accurately aligned with the perforated area of the foil, using an optical mask aligner.

The pattern being printed is sharply defined by the edge of the emulsion, which, during the printing operation is in intimate contact with the surface of the substrate on which the print is deposited. The emulsion, being somewhat mechanically compliant, deforms slightly under the pressure of the printing operation and thereby accommodates slight irregularities in the surface of the substrate, so maintaining intimate contact therewith and preventing undesirable sideways flow of ink.

This is advantageous compared with forming all-metal screens by etching both ink feeder holes and the pattern to be printed in a solid foil, without the use of an emulsion. Such screens are too rigid to conform with local irregularities in a substrate surface. Compared with conventional woven mesh printing screens, the screen fabricated from a solid metal foil is dimensionally stable. This makes it possible to superimpose successively printed patterns in accurate register relative to each other. This is necessary in fabricating complex multilayer circuits.

It has been found possible to print metal conductor lines of width 50µ and at a pitch of 100µ using the screen of the present invention. The screen may be made from any suitable metal, including stainless steel, nickel and beryllium copper. A stainless steel foil of a thickness of 25µ has been used to produce the lines described above.

The holes may be chemically or electrochemically etched using conventional photoresists to define the

pattern of holes to be formed. The array of holes may extend over the whole area of the foil but it has been found advantageous to restrict the array holes to the area corresponding only to the print pattern. This results in a mechanically stronger screen.

Conventional printing screen emulsions are used to define the pattern to be printed. It has been found advantageous to blacken the surface of the etched metal foil with a non-reflective coating, such as a proprietary black nickel, before applying the emulsion. This reduces unwanted reflections from the bright metal surface when the emulsion is being exposed prior to development. Such reflections result in diffusion of the exposing radiation and prevents the development of a sharp image in the emulsion.

Foils are difficult to mount directly on to a printing frame. An effective method of ensuring uniform tension in a mounted foil is to bond the foil to a woven wire mesh stretched on a printing frame in the usual manner. Epoxy adhesive may be used for bonding the foil to the wire mesh. The wire mesh is cut away from the middle region of the foil where the printed pattern is positioned.

Although in the embodiment described above the holes are formed in the foil before the emulsion layer is deposited, it would alternatively be possible to produce the patterned emulsion layer first and then etch the holes in the foil through the pattern, possibly using the emulsion as an etching resist. It would, of course, be necessary to use an emulsion material which can withstand the etchant.

CLAIMS

1. A printing screen comprising a metal foil having an array of holes etched through it, and a layer of a screen printing emulsion applied to one surface of the foil and having a pattern formed in it by partial removal of the emulsion, the holes and the pattern being in accurate register with each other.

2. A printing screen according to claim 1, in which there is a continuous array of holes etched through the foil and in which, outside the region in which the screen printing emulsion is removed it completely blocks the holes.

3. A printing screen according to claim 1, in which the array of holes is only etched in the region in which the screen printing emulsion is removed.

4. A printing screen according to any one of the preceding claims, in which the pattern includes portions of different dimensions and the dimensions of the holes in the different portions vary and correspond to the dimensions of the different portions.

5. A printing screen according to claim 1, in which the thickness of the foil is in the range 10μ to 50μ.

6. A printing screen according to claim 1 or 2, in which the width of the holes etched through the foil is in the range 10μ to 50μ.

7. A printing screen according to any one of the preceding claims, in which the foil is formed of stainless steel, nickel or beryllium copper.

8. A printing screen according to any one of the preceding claims, in which the surface of the foil is rendered non-reflective before the emulsion is deposited on it.

9. A printing screen substantially as described with reference to the accompanying drawings.

10. A method of forming a printing screen, comprising the steps of etching a metal foil to form an array of holes through it; depositing a layer of a screen printing emulsion on a surface of the metal foil; and removing portions of the emulsion to form a pattern with the pattern in accurate register with the holes.

11. A method of forming a printing screen according to claim 10, in which a continuous array of holes is etched through the metal foil.

12. A method of forming a printing screen according to claim 10, in which the array of holes is only etched in the region in which the screen printing and emulsion is removed.

13. A method of forming a printing screen according to claim 10, 11 or 12, in which the pattern includes portions of different dimensions and in which the dimensions of the holes in the different portions vary and correspond to the dimensions of the different portions.

14. A method according to claim 7, inwhich the surface of the foil is rendered non-reflective before the emulsion is deposited on it.

15. A method according to claim 7 or 8, in which the step of etching a metal foil to form an array of holes is carried out prior to the deposition of the screen printing emulsion.

16. A method of forming a printing screen substantially as described with reference to the accompanying drawings.